

Mathematical Modelling Competency for Indonesian Students in Mathematics Education Programmes

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Abstract

Previous studies have documented that students have difficulties in mathematical modeling competency. The current research is an attempt to investigate the issue of student's mathematical modeling competency in pre-service mathematics teacher in Indonesia and its analysis in term of Cumulative Grade Points Average (CGPA) gap in Riau Province, Indonesia. The research involved a total of 100 pre-service teacher students in Universitas Islam Riau (UIR). A survey design was employed to investigate the students' mathematical modeling competency using questionnaire of mathematical modeling test. The quantitative data were statistically analyzed using the SPSS 22.0. The descriptive analysis included the percentage, mean and standard deviation while inferential analysis involved Pearson correlation analysis. The results indicated that pre-service mathematics teacher education in Indonesia had moderate level of mathematical modeling competency. However, using graphical representation and interpreting and relating the mathematical solution to the real world context are the most two difficulties in mathematical modeling. At the same time, there was not a significant relationship between CGPA and mathematical modeling competency.

Keywords

Mathematical Modeling Competency, Pre-Service Mathematics Teacher, CGPA

1. Introduction

Trend of increased reliance on digital technology influences education and training necessities. How to persuade students in authentic problem solving

involving complex systems within an interdisciplinary context is the new challenge (English, 2009). It is also necessary to ensure students to keep staying benefit from small group tutoring for related importance of solving complex problems in groups, versus undertaking routine tasks (Reeson, Mason, Sander-son, Bratanova, & Hajkowicz, 2016; Zakaria, Solfitri, Daud, & Abidin, 2013). However, since traditional forms of problem solving are seen as independent of the development of core mathematical concepts, understandings, and processes in which students do not have opportunity to investigate complex, messy and real-world data (English, Lesh, & Fennewald, 2008), application and modelling in mathematics classroom obtain strong support from several educational researcher during the last few decades (Niss, Blum, & Galbraith, 2007; Yuanita & Zakaria, 2016) especially using technology (Maat & Zakaria, 2011).

However, there are a large number of researches reported that students hold difficulties in mathematical modeling competency (Hidayat & Iksan, 2015; Mentzer, Huffman, & Thayer, 2014; Yew & Akmar, 2016). In particular, sub stage of modeling is transitioning from the real world to the mathematical model (Czocher, 2017), which finally causes weak conceptual understanding (Ghazali & Zakaria, 2011). For example, it is found that the main difficulties encountered by students who deal with word problems concern transforming problems into mathematical models, i.e., in horizontal mathematization while the main barrier concerns horizontal mathematization and formulating mathematical models in particular (Jupri & Drijvers, 2016). Others also documented that specifically low achievement students might already get stuck in the initial step of the modeling cycle and are unable to get in the step of carrying out mathematical procedures when solving a context-based task (Wijaya, Heuvel-Panhuizen, & Doorman, 2014). Teachers need to help sufficiently this group of students by understanding their difficulties in mathematics skill required in problem solving. In conclusion, students hold lack of experience related to real-life problem solving.

However, only few literatures have documented the level of mathematical modelling competency in pre-service mathematics teacher education in Indonesia (Hidayat & Iksan, 2015; Wijaya, Heuvel-Panhuizen, & Doorman, 2014). With this in mind, this present study is an attempt to investigate the level of mathematical modelling competency in preservice mathematics teacher in Universitas Islam Riau (UIR), Indonesia. The current research will also extend existing mathematical modelling competency literature by discussing mathematical modeling competency level of pre-service mathematics teacher education in Indonesia. Therefore, it is aimed in this study at examining the level of mathematical modelling competency in preservice teacher in Indonesia.

2. Mathematical Modeling Competency

Modelling competency is closely associated with the definition of the modelling process (Blomhoej & Jensen, 2003; Blum et al., 2007; Maaß, 2006). However, the mathematical modeling competency in the current research was evaluated

through eight elements: making simplifying assumptions, clarifying the goal, formulating the problem, assigning variables, parameters and constants, formulating mathematical statements, selecting a model, interpreting graphical representations, and relating back to the real situation (Haines, Crouch, & Davis, 2000; Haines & Crouch, 2001) which refer as micro assessment (Houston, 2007).

3. Methodology

Survey method was employed to collect students' information in the current research. Participants involved 100 students of a mathematics education program in Riau Province, Indonesia. Female participants were 89 (89%), whereas male participants were 11 (11%), with ages ranging from 18 to 22 years old. The gender disproportion in the department of mathematics education program resulted in a large proportion of female participants. The mathematical modelling test was originally developed by Haines and Crouch (2001) and includes the following items: making simplifying assumptions (MMC1), clarifying the goal (MMC2), formulating the problem (MMC3), assigning variables, parameters and constants (MMC4), formulating mathematical statements (MMC5), selecting a model (MMC6), interpreting graphical representations (MMC7), and relating back to the real situation (MMC8). Each correct answer for multiple-choice items was awarded 2 points, and partial credit were awarded 1 point. Wrong answers were awarded 0 points. A total of 22 questions were used in the mathematical modelling test, which had a maximum score of 44. The reliability value of the mathematical modeling test (0.82) is good (Tavakol & Dennick, 2011). Hence, in the research, each item of the mathematical modeling competency was retained to examine the mathematical modeling competency of students. A large number of researchers have employed the mathematical modeling instrument with various objectives to measure students' mathematical modeling competency both in secondary and tertiary students (see Frejd & Ärlebäck, 2011; Fu & Xie, 2013; Kaiser, 2007; Lingefjärd & Holmquist, 2005). We use the statistical program SPSS 24.0 for descriptive analysis, Pearson correlation analysis and one-way MANOVA for comparison.

4. Result

The mean and standard deviation of the students' total score are summarized in **Table 1**. The students scored in average 0.89 (SD 0.31), with a minimum scores were 0.00, meanwhile a maximum scores were 2.00.

Moreover, **Figure 1** indicated the students' score in sub-competency of mathematical modeling.

As seen in **Figure 1**, the mean values for mathematical modeling competency, which varied among sub-competencies (making simplifying assumptions, $M = 1.12$, clarifying the goal, $M = 0.66$, formulating the problem, $M = 0.68$, assigning variables, parameters and constants, $M = 0.67$, formulating mathematical statements, $M = 0.82$, selecting a model, $M = 0.79$, interpreting graphical

representations, $M = 0.52$, and relating back to the real situation, $M = 0.57$). In addition, **Table 2** showed that there was not a significant relationship between CGPA and mathematical modeling competency $r = 0.083$ and $\text{sig.} = 0.409$ ($p > 0.01$).

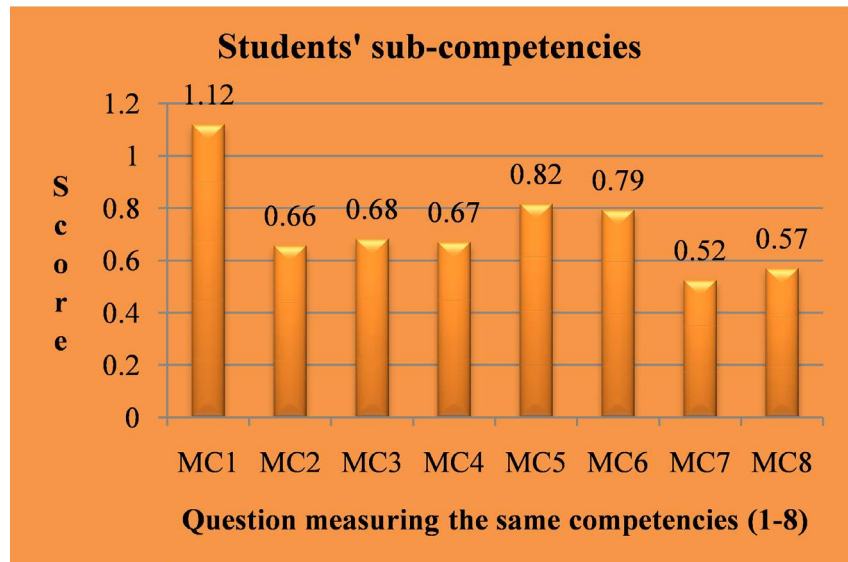


Figure 1 Students' sub-competencies.

Table 1. Means and standard deviations of scores on the mathematical modeling competency.

| Results | |
|----------------|------|
| Mean | 0.89 |
| Std. Deviation | 0.31 |
| Minimum | 0.00 |
| Maximum | 2.00 |

Table 2. Pearson correlation between CGPA and mathematical modeling competency.

| | CGPA | Mathematical Modeling Competency |
|----------------------------------|---------------------|----------------------------------|
| CGPA | Pearson Correlation | 1 |
| | Sig. (2-tailed) | 0.083 |
| | N | 100 |
| Mathematical Modeling Competency | Pearson Correlation | 0.083 |
| | Sig. (2-tailed) | 1 |
| | N | 100 |

5. Discussion

In the current research, comparing the sub-competencies of mathematical modeling competency in pre-service mathematics teacher in Indonesia, the results indicated that pre-service mathematics teacher education in Indonesia had moderate level of mathematical modeling competency. **Figure 1** revealed that they were most competent in questions relating to making simplifying assumptions and formulating mathematical statements, but exhibited more difficulties in questions relating to interpreting graphical representations, and relating back to the real situation. We identified the difficulties that students encountered in the process of mathematical modelling competency, which will assist the teacher to improve by selecting the most appropriate strategy (Haines & Crouch, 2013). For the sub-competence of MMC7, this finding coincides with the findings of the studies performed by Frejd and Ärleback (2011), and Kaiser (2007). However, our research was not in line with Frejd & Ärleback's (2011) findings in which they reported that making simplifying assumptions and formulating mathematical statements were more difficult for secondary school student. We found that this competency was most proficient for tertiary level students. One of possible reasons, for example, is that students in undergraduate level had a strong mathematics background so they had adequate knowledge of mathematical lessons easily in term of formulating mathematical statements. Another explanation of this result might be closely associated with experience in mathematical modeling competency such as the students' last-taken mathematics course (Frejd & Ärleback, 2011).

Relationship between Cumulative Grade Points Average (CGPA) and mathematical modelling competency in the current research was not significant, based on Pearson correlation analysis. The results obtained in this small-survey study did resonate with the findings reported in the large body of empirical studies that indicate student who is successful in conventional standardized mathematics assessments cannot predict the success in mathematical modeling task (Fu & Xie, 2013). The possible reason why this happens is not very clear and requires further examination and discussion using a more sophisticated statistical analysis.

6. Conclusion and Suggestion

The findings of present research provide further evidence that mathematical modeling competency for Indonesian students in mathematics education programmes had moderate level of mathematical modeling competency. Nonetheless, using graphical representation and interpreting and relating the mathematical solution to the real world context are the most two difficulties in mathematical modeling. No significant difference is observed between male and female students in all mathematical modeling competency sub-constructs. Moreover, there was not a significant relationship between CGPA and mathematical modeling competency. One of the practical implications is that teachers can present a

suitable learning strategy to enhance the mathematical modeling competency. The finding of the current research will also contribute to the Ministry of Education in Indonesia with current data that would aid the ministry in making better policy decisions and applying educational strategies with greater certainty for the implementation of curriculum in University. Our research has some limitations. First, the definition of mathematical modeling competency employed in this study is slightly restricted. The current research involves mathematical modeling competency in a content perspective. Mathematical modeling competency in modeling as a vehicle should be analyzed. Hence, an experimental study involving mathematical modeling competency as a vehicle should be conducted.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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